to the scales of Kirchhoff's and of Angström's maps. Of the seventy new lines which are given in this list, there are two which are proved to belong to the chromosphere, and not to be due to the exceptional elevation of matter to heights where it does not properly belong. No less than twenty of these lines are due to the metal titanium, and show the presence of titanium vapour in the prominences and chromosphere.

THE cultivation of beet-root sugar in France has now risen to an industry of the first importance. It employs more than 400 manufactories, and the process of manufacture is each year brought to a higher state of perfection. There are in France three or four journals specially devoted to subjects connected with the manufacture, its cultivation, its sale, the machinery required, the chemistry of the process, &c.

THE Fourth Annual Report is published of the Trustees of the Peabody Museum of American Archæology and Ethnology at Cambridge, U.S.A. Two important series of explorations have been carried out in the course of the past year on behalf of the Museum, by the Rev. F. O. Dunning in Eastern Tennessee, and by Dr. Berendt in Central America, resulting in valuable acquisitions to its collections. The Museum has also been enriched during the year by the gift of the "Charles Hammond Collection" from the towns of Chatham and Rochester, Cape Cod, and by a very valuable series of about 125 objects from the conservator of the Christy collection in London, consisting of original specimens and casts from Les Eyzies, La Madelaine, and Le Moustier, in the department of Dordogne, France. The Report is accompanied by a set of comparative measurements of crania from Peru, presented by Mr. Squier, of those from the mounds of Kentucky obtained by Mr. Lyon, and from the mounds of Florida.

THE Annual *Conversazione* of the Royal Society of Victoria was held on August 14, when the president, Mr. R. L. J. Ellery, delivered an address, in which he referred especially to the scientific results of the eclipse of last winter, and the preparations making in Australia for observing the eclipse of next month, to Prof. Heis's observations on the correspondence of auroral phenomena in the southern and northern hemispheres, to Dr. von Mueller's botanical researches in the colony, to the very important subject, economically, to the colony of the preservation of meat, and to Prof. Tyndall's germ theory of disease.

THE Report is published of the Annual Meeting of the Academy of Sciences of Vienna, held on the 30th of May, 1871, containing a review of the proceedings of the various departments of the Academy during the past year. The Academy has also issued its "Almanack," with list of home, foreign, and honorary members.

A SUPPLEMENT to the Sixth and Seventh Annual Report of the "Verein für Erdkunde" at Dresden, by D. Abendroth, contains a very interesting series of maps, illustrating the extent of geographical knowledge of the world possessed at different periods from A.D. 1350 to 1566.

A WORK has come out in Holland which particularly interests those who are engaged in the treatment of sewage manure. It is by M. J. A. C. Eschauzler, and gives all the results of the centuries of experience in the Netherlands. It is copiously illustrated.

WE are informed that the German translation of Tylor's "Primitive Culture" is not by Dr. Spengel, but conjointly by Herr Spengel and Herr Poske.

A NEW class for civil engineering has been formed in the Presidency College, Calcutta.

THE Madras Government has allowed 200*l.* for the expense of bringing the Assistant Government Astronomers to England to learn celestial photography.

THE GEOGNOSY OF THE APPALACHIANS AND THE ORIGIN OF CRYSTALLINE ROCKS[*]

II.

THE characteristic examples already given of symmetrical and asymmetrical envelopment are cited from a great number of others which might have been mentioned. Very many of these are by the pseudomorphists regarded as results of partial alteration. Thus, in the case of associated crystals of andalusite and cyanite, Bischof does not hesitate to maintain the derivation of andalusite from the latter species by an elimination of quartz; more than this, as the andalusite in question occurs in a granite-like rock, he suggests that itself is a product of the alteration of orthoclase. In like manner the mica, which in some cases coats tourmaline, and in others fills hollow prisms of this mineral, is supposed to result from a subsequent alteration of crystallised tourmaline. So in the case of shells of leucite filled with feldspar, or of garnet enclosing epidote or chlorite or quartz, a similar transformation of the interior is supposed to have been mysteriously effected, while the external portion of the crystal remains intact. Again the aggregates of tinstone, quartz and orthoclase having the form of the latter, are, by Bischof and his school, looked upon as results of a partial alteration of previously formed orthoclase crystals. It needed only to extend this view to the crystals of calcite enclosing sand-grains, and regard these as the result of a partial alteration of the carbonate of lime. There is absolutely no proof that these hard crystalline substances can undergo the changes supposed, or can be absorbed and modified like the tissues of a living organism. It may, moreover, be confidently affirmed that the obvious facts of envelopment are adequate to explain all the cases of association upon which this hypothesis of pseudomorphism by alteration has been based. Why the change should extend to some parts of a crystal and not to others, why in some cases the exterior of the crystal is altered, while in others the centre alone is removed and replaced by a different material, are questions which the advocates of this fanciful hypothesis have not explained. As taught by Blum and Bischof, however, these views of the alteration of mineral species have not only been generally accepted, but have formed the basis of the generally received theory of rock-metamorphism.

Protests against the views of this school have, however, not been wanting. Scheerer, in 1846, in his researches in Polymeric Isomorphism,[†] attempted to show that iolite and aspasiolite, a hydrous species which had been looked upon as resulting from its alteration, were isomorphous species crystallising together, and, in like manner, that the association of olivine and serpentine in the same crystal, at Snarum in Norway, was a case of envelopment of two isomorphous species. In both of these instances he maintained the existence of isomorphous relations between silicates in which 3HO replaced MgO. He hence rejected the view of Gustav Rose that these serpentine crystals were results of the alteration of olivine, and supported his own by reasons drawn from the conditions in which the crystals occur. In 1853 I took up this question, and endeavoured to show that these cases of isomorphism described by Scheerer entered into a more general law of isomorphism pointed out by me among homologous compounds differing in their formulas by nM_2O_2 (M = hydrogen or a metal). I insisted, moreover, on its bearing upon the received views of the alteration of minerals, and remarked, "The generally admitted notions of pseudomorphism seem to have originated in a too exclusive plutonism, and require such varied hypotheses to explain the different cases, that we are led to seek for some more simple explanation, and to find it, in many instances, in the association and crystallising together of homologous and isomorphous species."[‡] Subsequently, in 1860, I combated the view of Bischof, adopted by Dana, that "regional metamorphism is pseudomorphism on a grand scale," in the following terms:—

"The ingenious speculations of Bischof and others, on the possible alteration of mineral species by the action of various saline and alkaline solutions, may pass for what they are worth, although we are satisfied that by far the greater part of the so-called cases of pseudomorphism in silicates are purely imaginary, and, when real, are but local and accidental phenomena. Bischof's notion of the pseudomorphism of silicates like feldspars and pyroxenes, presupposes the existence of crystalline rocks, whose generation this neptunist never attempts to explain, but takes his starting-point from a plutonic basis."

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[*] Address of Prof. T. Sterry Hunt on retiring from the office of President of the American Association for the Advancement of Science; abridged from the "American Naturalist."

[†] Pogg. Annal., lxviii. 319.

[‡] Ibid.

I then asserted that the problem to be solved in regional metamorphism is the conversion of sedimentary strata, "derived by chemical and mechanical agencies from the ocean waters and pre-existing crystalline rocks into aggregations of crystalline silicates. These metamorphic rocks, once formed, are liable to alteration only by local and superficial agencies, and are not, like the tissues of a living organism, subject to incessant transformations, the pseudomorphism of Bischof."[*]

I had not, at that time, seen the essay by Delesse on pseudomorphs already referred to, published in 1859, in which he maintained views similar to those set forth by me in 1853 and 1860, declaring that much of what had been regarded as pseudomorphism had no other basis than the observed associations of minerals, and that often "the so-called metamorphism finds its natural explanation in envelopment." These views he ably and ingeniously defended by a careful discussion of the whole range of facts belonging to the history of the subject.

My own expression of opinion on this question, in 1853, had been privately criticised, and I had been charged with a want of comprehension of the question. It was, therefore, with no small pleasure, that I not only saw my views so ably supported by Delesse, but read the language of Carl Friedrich Naumann, who in 1861 wrote to Delesse as follows, referring to his essay just noticed :—

"You have rendered a veritable service to science in restricting pseudomorphs to their true limits, and separating what had been erroneously united to them. As you have remarked, envelopments have, for the most part, nothing in common with pseudomorphs, and it is inconceivable that they have been united by so many mineralogists and geologists. It appears to me, moreover, that they commit an analogous error when they regard gneisses, amphibolites, &c., as being, all of them, the results of metamorphic epigenesis, and not original rocks. It is precisely because pseudomorphism has been so often confounded with metamorphism that this error has found acceptance. I only admit a pseudomorph where there is some crystal the form of which has been preserved. There are very many metamorphic substances which are, in no sense of the word, pseudomorphs. Had the name of crystalloid been chosen instead of pseudomorph, this confusion would certainly have never found its way into the science. I think, with you, that the envelopment of two minerals is most generally explained by a contemporaneous and original crystallisation. Secondary envelopments, however, exist, and such may be called pseudomorphs or crystalloids, if they reproduce exactly the form of the crystal enveloped, whether this last still remains, or has entirely disappeared."[†]

It is unnecessary to remark that the view of Delesse and Naumann—viz. : that the so-called cases of pseudomorphism, on which the theory of metamorphism by alteration has been built, are, for the most part, examples of association and envelopment, and the result of a contemporaneous and original crystallisation—is identical with the view suggested by Scheerer, and generalised by myself long before, when, in 1853, I sought to explain the phenomena in question by "the association and crystallising together of homologous and isomorphous species."

Later in 1862, I wrote as follows :—

"Pseudomorphism, which is the change of one mineral species into another, by the introduction or the elimination of some element or elements, presupposes metamorphism (*i.e.*, metamorphic or crystalline rocks), since only definite mineral species can be the subjects of this process. To confound metamorphism with pseudomorphism, as Bischof and others after him have done, is therefore an error. It may be further remarked, that, although certain pseudomorphic changes may take place in some mineral species, in veins and near the surface, the alteration of great masses of silicated rocks by such a process is as yet an unproved hypothesis."[‡]

Thus this unproved theory of pseudomorphism, as taught by Bischof, does not, even if admitted to its fullest extent, advance us a single step toward a solution of the problem of the origin of the various silicates, which, singly or intermingled, make up beds in the crystalline schists. Granting, for the sake of argument, that serpentine results from the alteration of olivine or labradorite, and steatite or chlorite from hornblende, the origin of these anhydrous silicates, which are the subjects of the supposed change, is still unaccounted for. The explanation of this shortsightedness is not far to seek ; as already remarked, Bischof, although a professed neptunist, starts from a plutonic basis. When the epigenic origin of serpentine and its related rocks was first taught, these were regarded as eruptive and unstratified, and it was easy to imagine intruded masses of dioritic and feldspathic rocks, which had become the subjects of alteration. As, however, the progress of careful investigation in the field has shown the stratified character of these serpentines, diallage-rocks, steatites, &c., and their intercalation among limestones, argillites, quartzites, gneisses, and mica-schists, and even among feldspathic and hornblendic strata, we are forced to reject, with Naumann, the notion of their epigenic derivation, and to regard them as original rocks.

This view brings us face to face with the problem of metamorphism as defined by me in 1860[*] (see *ante*). We must either admit that these crystalline schists were created as we find them, or suppose that they were once sands, clays, marls, &c. ; in a word, sediments of chemical and mechanical origin, which by a subsequent process have been consolidated and crystallised. Whence, then, come these silicates of magnesia, lime, and iron, which are the sources of serpentine, hornblende, steatite, chlorite, &c.? This is the question which I proposed in that same year, when, after discussing the results of my examinations of the tertiary rocks near Paris containing layers of a hydrous silicate of magnesia related to talc in composition, among unaltered limestones and clays, I remarked that it is evident "such silicates may be formed in basins at the earth's surface, by reactions between magnesian solutions and dissolved silica ;" and, after some further discussion, said, "further inquiries in this direction may show to what extent certain rocks composed of calcareous and magnesian silicates may be directly formed in the moist way."[†] Subsequently, in a paper on "The Origin of some Magnesian and Aluminous Rocks," printed in the "Canadian Naturalist" for June 1860,[‡] I repeated these considerations, referring to the well-known fact that silicates of lime, magnesia, and iron-oxyd are deposited during the evaporation of natural waters, including those of alkaline springs and of the Ottawa River. Having described the mode of occurrence of the magnesian silicate sepiolite, in the Paris basin, and the related quincite, containing some iron-oxyd and disseminated in limestone, I suggested that while steatite has been derived from a compound like sepiolite, the source of serpentine was to be sought in another silicate richer in magnesia ; and, moreover, that chlorite, unless the result of a subsequent reaction between clay and carbonate of magnesia, was directly formed by a process analogous to that which (according to Scheerer) has, in recent times, caused the deposition from waters of neolite, a hydrous alumino-magnesian silicate, approaching to chlorite in composition,[§] "the type of a reaction which formerly generated beds of chlorite in the same way as those of sepiolite or talc." Delesse, subsequently, in 1861, in his essay on Rock-Metamorphism, insisted upon the sepiolites or so called magnesian marls, as probably the source of steatite, and suggested the derivation of serpentine, chlorite, and other related minerals of the crystalline schists, from deposits approaching these marls in composition.[‖] He recalled, also, the occurrence of chromic oxyd, a frequent accompaniment of these magnesian minerals, in the hydrated iron ores of the same geological horizon with the magnesian marls in France. Delesse did not, however, attempt to account for the origin of these deposits of magnesian marls, in explanation of which I afterwards verified Bischof's observations on the sparing solubility of silicate of magnesia, and showed that silicate of soda, or even artificial hydrated silicate of lime, when added to waters containing magnesian chlorid or sulphate, gives rise, by double decomposition, to a very insoluble magnesian silicate.[¶]

To explain the generation of silicates like labradorite, scapolite, garnite, and saussurite, I suggested that double aluminous silicates allied to the zeolites might have been formed, and subsequently rendered anhydrous. The production of zeolitic minerals observed by Daubrée at Plombières and Luxeuil by the action of a silicated alkaline water on the masonry of ancient Roman baths, was appealed to by way of illustration. It had there been shown by Daubrée that the elements of the zeolites had been derived in part from the waters, and in part from the mortar, and even the clay of the bricks, which had been attacked, and had entered into combination with the soluble matters of the water to form chabazite. I, however, at the same time pointed out another source of silicated minerals, upon which I had insisted since 1857, viz., the reaction between silicious or argillaceous matters and earthy carbonates in the presence of alkaline solutions. Numerous experiments showed that when solutions of an alkaline carbonate were heated with a mixture of silica and carbonate of magnesia, the alkaline silicate formed acted upon the latter, yielding a silicate of magnesia, and regenerating the alkaline carbonate; which, without entering into permanent combination, was the medium through which the union of the silica and the magnesia was effected. In this way I endeavoured to explain the alteration, in the vicinity of a great intrusive mass of dolerite, of a gray Silurian limestone, which contained, besides a little carbonate of magnesia and iron-oxyd, a portion of very silicious matter, consisting apparently of comminuted orthoclase and quartz. In place of this, there had been developed in the limestone, near its contact with the dolerite, an amorphous greenish basic silicate, which had seemingly resulted from the union of the silica and alumina with the iron-oxyd, the magnesia, and a portion of lime. By the crystallisation of the products thus generated it was conceived that minerals like hornblende, garnet, and epidote might be developed in earthy sediments, and many cases of local alteration explained. Inasmuch as the reaction described required the intervention of alkaline solutions, rocks from which these were excluded would escape change, although the other conditions might not be wanting. The natural associations of minerals, moreover, led me to suggest that alkaline solutions might favour the crystallisation of aluminous silicates, and thus convert mechanical sediments into gneisses and mica-schists. The ingenious experiments of Daubrée on the part which solutions of alkaline silicates, at elevated temperatures, may play in the formation of crystallised minerals, such as feldspar and pyroxene, were posterior to my early publications on the subject, and fully justified the importance which, early in 1857, I attributed to the intervention of alkaline silicates in the formation of crystalline silicated minerals.[*]

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[*] Amer. Jour. Sci., II. xxx. 135.

[†] Bull. Soc. Geol. de France, II. xviii. 678.

[‡] Descriptive Catalogue, Crystalline Rocks of Canada, p. 80, London Exhibition, 1862 ; also Dublin Quar. Jour., July 1863, and Amer. Jour. Sci., II. xxxvi. 218.

[*] Amer. Jour. Sci., II. xxx. 135.

[†] Ibid., II. xxix. 284 ; also II. xl. 49.

[‡] Ibid., II. xxxii. 286.

[§] Pog. Annal., lxxi. 288.

[‖] Etudes sur le Metamorphisme, 4to, pp. 91. Paris, 1861.

[¶] Amer. Jour. Sci., II. xl. 49.

While, however, there is good reason to believe that solutions of alkaline silicates or carbonates have been efficient agents in the crystallisation and molecular re-arrangement of ancient sediments, and have also played an important part in the local alteration of sedimentary strata which is often observed in the vicinity of intrusive rocks, it is clear to me that the agency of these solutions is less universal than was once supposed by Daubrée and myself, and will not account for the formation of various silicated rocks found among crystalline schists, such as serpentine, hornblende, steatite, and chlorite. When I commenced the study of these crystalline strata, I was led, in accordance with the almost universally received opinion of geologists, to regard them as resulting from a subsequent alteration of palæozoic sediments, which, according to different authorities, were of Cambrian, Silurian, or Devonian age. Thus in the Appalachian region, as we have already seen, they have, on supposed stratigraphical evidence, been successively placed at the base, at the summit, and in the middle of the Lower Silurian or Champlain division of the New York system. A careful chemical examination among the unaltered palæozoic sediments, which in Canada were looked upon as the stratigraphical equivalents of the bands of magnesian silicates in these crystalline schists, showed me, however, no magnesian rocks except certain silicious and ferruginous dolomites. From a consideration of reactions which I had observed to take place in such admixtures in presence of heated alkaline solutions, and from the composition of the basic silicates which I had found to be formed in silicious limestones near their contact with eruptive rocks, I was led to suppose that similar actions, on a grand scale, might transform these silicious dolomites of the unaltered strata into crystalline magnesian silicates.

Further researches, however, convinced me that this view was inapplicable to the crystalline schists of the Appalachians; since, apart from the geognostical considerations set forth in the previous part of this paper, I found that these same crystalline strata hold beds of quartzose dolomite and magnesian carbonate, associated in such intimate relations with beds of serpentine, diallage, and steatite, as to forbid the notion that these silicates could have been generated by any transformations or chemical re-arrangement of mixtures like the accompanying beds of quartzose magnesian carbonates. Hence it was that already, in 1860, as shown above, I announced my conclusion that serpentine, chlorite, and steatite had been derived from silicates like sepiolite, directly formed in waters at the earth's surface, and that the crystalline schists had resulted from the consolidation of previously formed sediments, partly chemical and partly mechanical in their origin. The latter being chiefly silico-aluminous, took, in part, the forms of gneiss and mica-schists, while from the more argillaceous strata, poorer in alkali, much of the aluminous silicate crystallised as andalusite, staurolite, cyanite, and garnet. These views were reiterated in 1863,[*] and further in 1864, in the following language, as regards the chemically-formed sediments: "steatite, serpentine, pyroxene, hornblende, and in many cases, garnet, epidote, and other silicated minerals are formed by a crystallisation and molecular re-arrangement of silicates generated by chemical processes in waters at the earth's surface."[†] Their alteration and crystallisation were compared to that of the mechanically formed feldspathic, silicious, and argillaceous sediments just mentioned.

(*To be continued.*)

THE RELATIONS BETWEEN ZOOLOGY AND PALÆONTOLOGY[‡]

MY distinguished predecessor, the late Prof. E. Forbes, appears to have been the first who undertook the systematic study of marine zoology with reference to the distribution of marine animals in space and in time. After making himself well acquainted with the fauna of the British seas to the depth of about 200 fathoms by dredging, and by enlisting the active co-operation of many friends, among whom we find MacAndrew, Barlee, Gwyn Jeffreys, William Thompson, and many others, entering enthusiastically into the new field of natural history inquiry; in the year 1841, Forbes joined Captain Graves, who was at that time in command of the Mediterranean Survey as naturalist. During about eighteen months he studied with the utmost care the conditions of the Ægean and its shores, and conducted upwards of 100 dredging operations at depths varying from 1 to 130 fathoms. In 1843 he communicated to the Cork meeting of the British Association an elaborate report on the mollusca and radiata of the Ægean Sea, and on their distribution as bearing on geology. Three years later, in 1846, he published in the first volume of the "Memoirs of the Geological Survey of Great Britain," a most valuable memoir upon the connection between the existing Fauna and Flora of the British Isles and the geological changes which have affected their area, especially during the epoch of the northern drift. In the year 1859 appeared the "Natural History of the European Seas," by the late Prof. Edward Forbes, edited and continued by Robert Godwin-Austen. In the first hundred pages of this little book Forbes gives a general outline of some of the more important of his views with regard to the distribution of marine forms. The remainder of the book is a continuation by his friend Mr. Godwin-Austen, for before it was finished an early death had cut short the career of the most accomplished and original naturalist of his time. I will give a brief sketch of the general result to which Forbes was led by his labours, and I shall have to point out that, although we are now inclined to look somewhat differently on certain very fundamental points, and, although recent investigations with better appliances and more extended experience have invalidated many of his conclusions, to Forbes is due the credit of having been the first to treat these questions in a broad philosophical sense, and to point out that the only means of acquiring a true knowledge of the *rationale* of the distribution of our present fauna is to make ourselves acquainted with its history, to connect the present with the past. This is the direction which must be taken by future inquiry:—Forbes as a pioneer in this line of research was scarcely in a position to appreciate the full value of his work. Every year adds enormously to our stock of data, and every new fact indicates more and more clearly the brilliant results which are to be obtained by following his methods, and by emulating his enthusiasm and his indefatigable industry. Forbes believed implicitly, along with nearly all the leading naturalists of his time, in the immutability

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[*] Proc Roy. Soc., May 7, 1857. Amer. Jour. Sci., II. xxiii. 438, and xxv. 289 and 435.

[*] Geol. of Canada, pp. 577—581.

[†] Amer. Jour. Sci., II. xxxvii. 266, and xxxviii. 183.

[‡] Abstract of Opening Lecture on Natural History delivered at the University of Edinburgh, Nov. 2, by Prof. Wyville Thomson, F.R.S.